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The Impact of the LCR on the Interbank Money Market

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Abstract

This paper analyses the impact of the Basel 3 Liquidity Coverage Ratio (LCR) on the unsecured interbank money market and therefore on the implementation of monetary policy. Combining two unique datasets, we show that banks which are just above/below their short-term regulatory liquidity requirement pay and charge higher interest rates for unsecured interbank loans. The effect is larger for longer maturities and increases after the failure of Lehman Brothers. During a crisis, being close to the minimum liquidity requirement induces banks to decrease lending volumes. Given the high importance of a well-functioning interbank money market, our results suggest that the current design of the LCR is likely to dampen the effectiveness of monetary policy.

Keywords: Monetary Policy, Interbank Market, Basel 3
JEL classification: G21, E42, E43

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1. Introduction

In December 2010 the Basel Committee for Banking Supervision (BCBS) drafted a new regulatory framework[1] (henceforth Basel 3) with the purpose to achieve a more stable and less vulnerable banking system. Besides new rules for capital and leverage, the framework also specifies a short- and a long-term liquidity requirement as key concepts to reinforce the resilience of banks to liquidity risks.

The Liquidity Coverage Ratio (LCR) is a short-term ratio which requires financial institutions to hold high quality liquid assets to meet short-term obligations which are caused by sudden liquidity disruptions. Banks are required to hold an amount of highly liquid assets at least equal to their net cash outflows over a 30-day stress period. The Net Stable Funding Ratio (NSFR) requires institutions to hold a minimum amount of funding that is expected to be stable over a one year time horizon based on liquidity risk factors assigned to assets and off-balance sheet liquidity exposures greater than its required amount of stable funding. The NSFR is intended to promote longer-term structural funding of banks' balance sheets, off-balance sheet exposures and capital markets activities.

The rationale and motivation behind the LCR are well known. Prior to the financial crisis in 2008, asset markets were liquid and funding was easily available at low cost. However, the emergence of the crisis showed how rapidly market conditions can change, leading to a situation that several institutions - regardless of appropriate capital levels - experienced severe liquidity issues, forcing either an intervention by the responsible central bank or a shutdown of the institution. While the purpose of the LCR is straightforward, both its exact setup and the induced side-effects are still controversial. Summarizing, the discussion mainly focuses on the questions whether the LCR leads to: a) an increase in the yield spreads between differently classified assets with respect to liquidity and/or maturity, b) a general increase in interest rates, c) a decline in banks' lending, something akin to a credit crunch or d) possible consequences for the interbank market. Bini Smaghi (2010) argues that the introduction of the LCR will increase the yield spreads between assets classified as liquid and the ones classified as illiquid. A similar effect can be expected

[1] See BCBS (2010a) and BCBS (2010b).

with regards to the maturity profiles. According to Bini Smaghi (2010), banks will try to pass on their increased operating costs due to the holding of highly liquid but low return assets to their clients: Tighter lending standards, higher lending rates and active shedding of loans are the consequences. Went (2010) argues that meeting the LCR will lead to reduced earning yields which in turn reduces those of the individual bank but also of the aggregate banking sector.

Schmitz (2009), Schmitz (2010) as well as Bindseil and Lamoot (2011) argue that the introduction of the LCR generally sets incentives for banks to decrease lending and borrowing in the unsecured interbank money market due to their high run-off assumption which would require banks to hold large liquidity buffers balancing these outflows. Other observers argue that there would be no direct effect of the LCR on loans with maturities shorter than 30 days which make the largest part of the unsecured interbank money market. The reason for this is that any outflow (inflow) would be compensated by the respective inflow (outflow) within the LCR's 30-day horizon. For loans with maturities longer than 30 days no repayments would occur within the horizon of the LCR and therefore these loans would have a direct effect. In any case, a shrinking of the unsecured interbank money market would hamper the allocation and distribution of liquidity and therefore negatively affect the liquidity risk exposure and liquidity risk absorption capacity of banks. Further Bindseil and Lamoot (2011) argue that due to the reduction of liquidity in the unsecured money market the role of EONIA in monetary policy implementation should be questioned. According to Schmitz (2011), the ECB, the Federal Reserve as well as the Bank of England rely on the interbank money market interest rate as operating targets in monetary policy implementation. This is confirmed by Borio (2001) who shows that central banks implement monetary policy by manipulating the interbank money market interest rates through open market operations and therefore any price or volume movement in the interbank money market could severely affect the effectiveness of monetary policy.

In 2003, De Nederlandsche Bank (DNB) introduced a quantitative liquidity rule 8028 (henceforth DLCR).[2] Under the DLCR, a bank's actual liquidity must exceed required liquidity, at horizons of both one week and one month. Using the

[2]See DNB (2003).

regulatory liquidity requirement DLCR as proxy for the LCR in combination with confidential data on interbank borrowing and lending in the Dutch interbank market, a set of controls accounting for the riskiness of an institution and its business model, the purpose of this paper is to show whether the introduction of a quantitative liquidity rule leads to higher interest rates and lower lending volumes in the unsecured interbank money market. This paper adds to the literature as it is the only study, which provides empirical evidence on the impact of a quantitative liquidity rule on the interbank money market and therefore on the implementation of monetary policy.

The main results can be summarized as follows: A bank which is close to its minimum liquidity requirement asks and pays higher interest rates for loans in the unsecured interbank money market. These results also hold when controlling for an institution's perceived riskiness, size and business model. Both effects increase after the failure of Lehman Brothers and are larger for maturities longer than the 30-day horizon of the LCR. During stress, being just above/below the prudential liquidity requirement induces a negative impact on lending volumes.

2. Literature Review

Starting with the collapse of Lehman Brothers on September 15th 2008, the world has been subject to a global financial crisis, which affected all economies around the globe. Since then, there has been a debate about causes, consequences and possible countermeasures.[3] Apart from its geographical dimension, the great interest in this crisis also mitigated a discussion about the fundamental fragility and vulnerability of the financial system as such.

Giavazzi and Giovannini (2011) argue for instance that the fragility of financial markets mainly stems from their role for liquidity transformation. Liquidity transformation links the financing of long-term funding for productive investments via the pooling of agents with different transactional needs. However, once many short-term depositors want to withdraw their money simultaneously, the value of liquid investments is likely to fall short compared to short-term debt. A bank-run

[3] See for instance Reinhart and Rogoff (2008), Crotti (2009), Diamond and Rajan (2009) and Hume and Sentance (2009).

materializes with severe consequences for the stability of the financial market and society as such. According to the seminal contribution of Diamond and Dybvig (1983) banks are forced into fire sales due to the ability of depositors to withdraw their funds, exposing banks to self-fulfilling panics. Once the funding for long-term projects dries up, production will be less efficient resulting in lower income for everybody

Illustrating the issue of liquidity transformation and the fragility of financial markets with several examples based on Holmstrom and Tirole (2011) as well as Diamond and Dybvig (1983), Giavazzi and Giovannini (2011) argue that the main challenge of regulators is to minimize the likelihood of liquidity transformation to break down. A widely used instrument to deal with these issues is the introduction of a deposit insurance scheme, which makes retail deposits a safer form of funding. However, as noted by Ayadi and de Groen (2012) more stable forms of funding can only help a bank grow up to a certain point and thus banks will still heavily rely on short-term (interbank) funding which also allows them to manage their balance sheets pro-cyclically.[4]

Since the announcement of the BCBS to introduce new regulations for capital and liquidity, several streams of academic and policy-oriented literature have been discussing possible long- and short-term impacts of the reform. MAG (2010a) and MAG (2010b) assess the macroeconomic impact of tighter capital and liquidity requirements during the transition phase. Modeling the direct effect of a liquidity rule as a 25% increase in the holding of liquid assets combined with increased maturities of banks' wholesale liabilities, the authors find a 14 basis point increase in the median lending spread and a fall in lending volumes of 3.2%. Analysing the duration of the transition period, the studies find a negative relation between magnitude of the effects and duration of the transition period. Both studies fail to take into account that by definition new liquidity regulations (should) lead to stronger and more stable banks which might lower their funding costs and therefore dampen the increase in lending spreads and other negative side effects. Further, banks will seek to improve their efficiency and therefore cutting non-interest expenses, which in turn might lower the increase in lending spreads. On the other hand, the in-

[4] See for instance Adrian and Shin (2010).

creased demand for liquid assets could possibly increase the price and therefore the costs to meet the liquidity rules.

Recent microeconomic studies concerning banks' liquidity management have focussed on several aspects such as the management of reserve requirements (Bartolini et al. (2001), Jallath-Coria et al. (2002)), the transformation of short-term liabilities into liquid assets (Berger and Bouwman (2009)) as well as securities holdings and cash balances (Aspachs et al. (2005), Freedman and Click (2009)). The way banks manage their overall liquidity under a quantitative liquidity requirement is shown in De Haan and Van den End (2012) as well as Schertler (2010). Using quarterly data for three types (commercial, savings and cooperative) of German universal banks from 2000-2008, Schertler (2010) analyses banks' liquidity management under the quantitative German measure. The idea behind the German liquidity ratio (LR) is very similar to the Dutch 8028 as well as the LCR. Under the LR banks are expected to hold sufficient regulatorily specified liquid assets to cover all payment obligations which mature or are assumed to run off within a one month period. Applying dynamic panel data regressions and looking specifically at banks which are close (just below/ above) the LR, the author finds that close banks (dependent on their type) have higher securities holdings or higher repayments from loans in case they are subject to higher payment obligations. Further, close banks seem to differ from non-close banks in a way that they tend to more intensively reduce their long-term loans when they have higher contemporaneous payment obligations.

However, there exists no study which analyses the direct impact of a quantitative liquidity rule on the unsecured interbank money market. The purpose of this paper is to provide empirical evidence on banks' behaviour in the interbank market depending on their (non)-fulfilment of their regulatory liquidity requirement.

3. Data description

In order to analyse the effects of a quantitative liquidity requirement on the interbank market, we will bring together data on 1) DNB's monthly prudential liquidity reporting, 2) bilateral transactions in the interbank market for different maturities (volumes and prices) and 3) risk indicators and other measures calculated

from the balance sheet. We will discuss these data sources in turn.

3.1. Dutch Liquidity Coverage Ratio (DLCR)

As proxy of the LCR, we examine banks' liquidity holdings using monthly data of the prudential Dutch quantitative liquidity rule DLCR. Under the DLCR, a bank's actual liquidity must exceed required liquidity, at horizons of both one week and one month. For the purpose of this analysis, we calculate ratios of actual over required liquidity. Actual liquidity is defined as the stock of liquid assets minus haircuts plus recognised cash inflows weighted by degree of liquidity. Required liquidity is defined as the assumed calls on contingent liquidity lines, assumed withdrawals of deposits, assumed drying up of wholesale and derivative funding. The current legislation of the DLCR allows banks to include Residential Mortgage Backed Securities (RMBS) as part of the liquidity buffer while the LCR does (currently) not allow the inclusion of RMBS. Further, with respect to deposits and contrary to the DLCR, the LCR distinguishes "stable" and "less stable" deposits which have different run-off rates under stress and are classified according to a set of predefined conditions. In order to limit the resilience on estimated inflows, the BCBS capped inflows to a maximum of 75% of outflows while the DLCR takes into account inflows to a full extent.[5]

The treatment of interbank loans is equal under the LCR and the DLCR. In case of loans with maturities of less than 30 days, there is likely to be no direct effect on either the LCR or the DLCR. If institution A receives a loan from institution B with a maturity of less than 30 days, the increase of institution A's liquidity buffer is offset by an increase of its cash outflows within the LCR's 30 day horizon. Similarly, institution B's declined liquidity buffer is compensated by a cash inflow from institution A's loan repayment.[6] In case of loans with maturities longer than 30 days neither inflows nor outflows occur within the LCR's 30 day horizon which leads to a situation that the borrowing bank can increase its liquidity buffer and therefore its LCR while institution B's LCR will decline. Given that, our analysis

[5] For a more in depth description of the DLCR, please refer to De Haan and Van den End (2012).

[6] For completion it needs to be mentioned that in contrast to the DLCR, the LCR cannot increase in case the institution is affected by the cap on inflows.

focuses on loans with maturities longer than 30 days.[7]

Limited by the number of banks active in the interbank money market, we use data for 61 Dutch banks from January 2004 to December 2011. To gain insight in whether the introduction of a quantitative liquidity requirement affects the interbank money market, we create a dummy which is 1 in case a bank's DLCR is between 90% (just below) and 110% (just above) and 0 otherwise. Over the whole sample period, we have 2391 observations and 536 cases (22%) in which a bank's liquidity ratio is between 90% and 110%. The average time a bank remains close to the requirement is 4.4 months, with a median of 2 months, a maximum of 54 and a minimum of 1 month.

3.2. Interbank Market

The interbank market works as an over-the-counter (OTC) market so prices and volumes are not publicly known. Financial institutions settle various types of payments in TARGET 2 (the interbank payment system of cross-border transfers within the EU), such as payments on behalf of customers, bank-to-bank payments, payment of the cash leg of a security trade, and pay-ins for the CLS system (continuous linked settlement) to settle foreign exchange transactions. In 2010, the Dutch part of TARGET 2 had 61 direct participants including a few large British banks, a daily average of 34.000 transactions and a daily turnover of 295 billion euro.The Dutch part of TARGET 2 constitutes roughly 13% (10%) of the complete TARGET system in terms of volume (transactions).

In a recent paper, Heijmans et al. (2010) describe how, based on these flows, loans can be identified and thus volumes and prices extracted. The authors build on the seminal paper by Furfine (1999) and improve the algorithm to include durations of up to one year.[8] The algorithm has been applied in the US using Fedwire (Demiralp et al. (2006), Ashcraft and Bleakley (2006), Hendry and Kamhi (2009)), Norway (Akram and Christophersen (2010)), and Germany (Braeuning (2011)).

The algorithm returns information on the borrowing and lending institution, paid

[7] The results for shorter maturities follow a similar pattern, however with smaller coefficients. All results for shorter maturities are available on request.

[8] For a more detailed description of the functioning of the algorithm, see Heijmans et al. (2010).

interest rates, total value as well as duration of the loan. In order to match the frequency of the liquidity data, we create monthly volume weighted averages of the interest rates per bank to calculate spreads with the respective ecb interest rate and monthly sums of the traded loans times maturity divided by total assets while in both cases just taking into account loans with maturities longer than 30 days.

3.3. Balance Sheet

Alongside with the new requirements for liquidity, the BCBS tightened the capital rules and newly introduced a leverage ratio. To map the new Basel requirements into the regression, we introduce a leverage ratio, which is defined as equity over total assets and a capital ratio which reflects the ratio of capital over risk weighted assets. For both of these measures we use (interpolated) monthly data per bank from January 2004 to December 2011 from DNB's prudential reporting.
Following a recent working paper by Hilscher and Wilson (2012) who show that a set of easily obtainable balance sheet measures outperform professional credit ratings and cds spreads, we include return on equity, profitability defined as the percentage of income over total assets and cash flows reflected by the percentage of cash over total assets to control for the riskiness of an institution. By definition the variables referring to Basel III, leverage and capital, are measures of solvency and therefore also reflect the riskiness of an institution. All variables are obtained from DNB's prudential reporting and cover January 2004 until December 2011.
The rationale behind including such a large amount of variables controlling for the riskiness of an institution is that there is broad consensus that a bank's activity in the interbank market is at least partially driven by its perceived riskiness. Therefore, controlling for the riskiness of an institution is essential when analysing the interbank market. A further reason to include cashflows and profitability is that these variables are correlated with the overall state of the economy which makes them suitable candidates to control for the possibility that the dependent variables and liquidity as the key independent variable are jointly driven by the current economic situation.

3.4. The Interbank Market before and after the failure of Lehman Brothers

In a recent working paper Heijmans et al. (2010) analyse the Dutch interbank market, based on four periods: 1) January 2004 until June 2007: financial markets

were quiet and well-functioning, 2) July 2007 until August 2008: first turmoils, 3) September 2008 until June 2009: failure of Lehman Brothers, followed by a severe period of stress and 4) July 2009 until December 2011: Unconventional monetary policy measures by the ECB. Looking at the developments in the interbank market and following the general policy discussions, it is sensible to simplify the distinction in a period before and a period after the the failure of Lehman Brothers.

Comparing the average interest rates paid in the Dutch interbank market with EONIA it becomes evident that before the failure of Lehman Brothers, the Dutch interest rate is highly correlated with EONIA. However, after the collapse of Lehman Brothers, the interest rates in the interbank market increase to a smaller extent than the European average, suggesting that the effect of Lehman Brother's failure is somewhat smaller for Dutch banks compared to the European average. Still and similar to the findings of Gorton (2009), the volatility and spreads of the interest rates increase considerably after the failure due to higher risk aversion in the market. Heijmans et al. (2010) find that the spreads of the Dutch interest rates increase from 7.1 basis points before the failure to 18.6 basis points after the failure of Lehman Brothers.

The average total turnover calculated as the sum of the total value of a loan times its maturity for maturities longer than 30 days decreases from EUR 3.8 billion in the period before the failure to EUR 2.64 billion in the period after the failure. The first upward trends can be observed in the summer of 2009. In this period, the ECB started injecting extra liquidity using unconventional monetary policy measures.

Summarizing, it can be seen that the credit crunch after the failure of Lehman Brothers led to higher interest rates, higher volatilities and lower volumes. Although the Dutch interbank market did not completely vanish and remained sufficiently active, it needs to be mentioned that a drawback of our analysis is that periodically the results might be heavily influenced by only a small number of banks. However, those banks which remain active in a relatively inactive market can be considered to be overproportionately strong and therefore (if anything) our results underestimate the effects of the quantitative liquidity requirement.

4. The Model

For the analyses with respect to interest rates, we apply panel regressions using fixed effects. Apart from the results of the Hausman test, the choice for fixed instead of random effects has three reasons: First, if the individual effect represents omitted variables, it is highly likely that these bank-specific characteristics are correlated with the other regressors. Second, we want to analyse the adjustments of banks' behaviour in the time variation and not in the cross-sectional variation of the data and third, our panel dataset includes very large to very small banks with large variations with respect to business models which in turn implies that differences among banks are not random. All employed models have the common feature that they rely on the fulfilment of the prudential quantitative liquidity requirement. The baseline equation takes the following form:

$$Y_{i,t} = \beta_0 + \beta_1 LOW_{i,t} + \beta_2 M_{i,t} + \beta_3 C_{i,t} + \beta_4 R_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$with\ \varepsilon_{i,t} = \mu_i + \eta_{i,t}$$

where $Y_{i,t}$ describes the dependent variable which is either the spread between the volume weighted average of the monthly interest rate charged (paid) by an institution when lending (borrowing) in the unsecured interbank money market with the respective ECB rate or the ratio of a bank's monthly total lending over total assets. The dummy variable $LOW_{i,t}$ allows us to gain insight whether a bank which is just above/below the regulatory liquidity requirement behaves differently in the interbank money market. The variable is 1 in case a bank's liquidity ratio is between 90% and 110% and 0 otherwise. This approach is in line with other studies dealing with the impacts of prudential regulation (Shrieves and Dahl (1992), Schertler (2010)).[9] $M_{i,t}$ is a vector giving more insight into the exact composition of the

[9]The rationale behind using a dummy instead of a continuous variable is that we would like to capture the direct effect of the fulfilment of the quantitative liquidity requirement instead of using a proxy for the liquidity position of an institution. The disadvantage of our dummy is that we are not able to distinguish between the behavioural changes of those banks which are still relatively close to the threshold and the ones very far away. In order to account for this issue, we include in our sensitivity checks the ratio of the DLCR as continuous variable.

dependent variables. It includes *LongLen* reflecting the share of loans with maturities longer than 30 days over total loans and an interaction term of *LOW* and *LongLen*. This setup allows us to separate the general effects of a quantitative liquidity rule from the effects on loans with maturities longer than 30 days. $C_{i,t}$ includes a dummy (*crisis*) which is 1 after the failure of Lehman Brothers and 0 otherwise alongside with an interaction term of *LOW* and *crisis*. Finally, $R_{i,t}$ is a vector of risk variables[10], namely profitability, cash-flow and return-on-equity as well as the Basel 3 measures leverage and regulatory capital following BCBS (2010b). As we use fixed effects estimations, we also model a bank specific effect μ_i and an *iid* disturbance term $\eta_{i,t}$.

5. Results

5.1. Lending Rates

Table 1 presents the estimation results for the spreads between the value weighted average of interest rates charged by banks for interbank lending and the respective ECB interest rate and whether these rates differ between banks which are just above/below the minimum liquidity requirement DLCR and banks for which this condition does not hold.

Column 1 shows that banks, which are just above/below (*LOW*) their regulatory liquidity requirement DLCR, charge significantly (1% level) higher interest rates when issuing a loan in the unsecured interbank money market. Interpreting the results, our analysis suggests that *LOW* banks charge 23 basis points more than their peers for interbank loans. In Column 2, we add the variable *LongLen* reflecting the share of loans with maturities longer than 30 days and total loans. The variable is significant on the 1% level, suggesting that a 10% increase of the share of loans with maturities longer than 30 days increases the lending rate by 1.2 basis points. Given that the variance of *LongLen* is 0.1, its effect is small but economically significant. The reason for this could either be that loans with longer maturities are considered to be more risky or all banks are more hesitant to issue loans which will

[10] In order to keep the focus on the liquidity requirement, we present in the body of the paper only the results when controlling for the profitability of an institution. In the Appendix several robustness checks are presented in which we control for different combinations of risk indicators.

Table 1: Effects of a quantitative liquidity rule on the Lending Rates in the interbank money market

VARIABLES	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
LOW	0.231***	0.300***	0.115**	0.110**	0.151**	-0.0329
	(0.0280)	(0.0298)	(0.0562)	(0.0554)	(0.0605)	(0.0348)
LongLen		0.114***	0.0567	0.0610	0.0609	0.0538
		(0.0359)	(0.0387)	(0.0383)	(0.0387)	(0.0517)
LongLenLOW			0.340***	0.325***	0.293***	0.172***
			(0.0873)	(0.0862)	(0.0943)	(0.0219)
profit				0.114***	0.110***	0.00265
				(0.0164)	(0.0164)	(0.00949)
Lev					-4.199	2.664
					(4.388)	(2.475)
Capital					0.000468**	-0.000115
					(0.000232)	(0.000131)
crisis						-0.763***
						(0.0141)
LOWcrisis						0.124***
						(0.0340)
Constant	0.795***	0.716***	0.743***	0.740***	0.771***	1.039***
	(0.0104)	(0.0225)	(0.0234)	(0.0232)	(0.0377)	(0.0218)
Observations	2229	1730	1730	1718	1571	1571
r2_w	0.0303	0.0613	0.0695	0.0917	0.100	0.717

*Note:Columns 1-6 present fixed effects panel estimations with the spread between the monthly volume weighted average interest rate and the respective ECB interest rate being the dependent variable. The purpose of the above regressions is to show whether banks which are just above/below (LOW) their quantitative liquidity requirement charge higher interest rates for lending in the unsecured interbank money market. To show this, we additionally control for the riskiness of an institution (profit defined as income over total assets) and the Basel III measures Lev (equity over total assets) and Capital (BIS capital ratio). Further, we include LongLen (share of loans with maturities longer than 30 days over total loans), LongLenLOW which is an interaction term of LOW and LongLen as well as crisis (dummy which is 1 after the failure of Lehman and 0 otherwise) and LOWcrisis which is an interaction term of LOW and crisis. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses.*

not be repaid within the LCR's 30 day horizon.

Column 3 shows the results when we additionally include *LongLenLOW*, the interaction term of *LOW* and *LongLen*. *LongLenLOW* enters the regression significantly on the 1% level, suggesting that a bank which is just below/above its quantitative liquidity requirement charges 3.4 basis points more in case the share of loans with maturities longer than 30 days increases by 10%. Comparing this outcome to the previous result in column 2 and given that *LongLenLOW* absorbs the significance of *LongLen*, our results suggest that that the previous effect of *LongLen* was mainly driven by *LOW* banks and that especially these banks charge more when issuing loans with longer maturities. The results in column 2 and 3 are a first indication that a quantitative liquidity rule indeed affects the interest rate in the unsecured interbank market in general but especially for longer maturities. Although it remains significant on the 5% level, *LOW* loses statistical and economic significance due to the inclusion of *LongLenLOW*. This suggests that the effect of a liquidity regulation on the interbank market is stronger for maturities longer than 30 days. This result is straightforward given that we can assume that for maturities longer than 30 days both effects hold, the general direct effect of a quantitative liquidity rule on the interbank market and a specific effect on loans with maturities longer than 30 days.

In Column 4, we add the variable $profit$ to the estimation equation.[11] Even when controlling for the riskiness of an institution, the compliance with the prudential liquidity requirement remains significant at the 5% level, however with a further decreased economic significance. *LongLenLOW* remains stable on the 1% level with only slightly decreased economic significance. The variable $profit$ is statistically significant on the 1% level with positive sign, suggesting that an absolute increase of a bank's profitability by 1% increases the lending rate by 11 basis points. Column 5 includes the other Basel 3 key concepts, *Lev* and $Capital$. Adding these two measures leads to an increase of the coefficient of *LOW* while *LongLenLOW* slightly decreases in terms of economic significance. $Capital$ enters the regres-

[11] The variables used to control for the riskiness of an institution are of high importance for this analysis. In order to remain focussed on the effects of a quantitative liquidity rule, we still decided to present only the results which include profitability in the body of this paper while the analyses including all risk controls can be found in the Appendix.

sion significant on the 5% level with very small coefficient which suggests that an increase of an institution's capital ratio by 1% increases the lending rate by less than 0.1 basis points. Both the economic insignificance and the positive sign of *Capital* are rather surprising given that there seems to be broad consensus that solvency plays an essential role in the interbank market. A potential explanation for this effect could be that institutions with severe solvency issues cannot borrow in the interbank market and do not have excess liquidity to lend to other banks. An institution's capital ratio therefore determines its access to the market but not its interest rate.

Column 6 additionally includes *crisis* as well as the interaction term *LOWcrisis* which entirely absorbs the significance of *LOW*. The quantitative liquidity regulation however still significantly affects lending rates given that it is a component of the two interaction terms *LongLenLOW* as well as *LOWcrisis* which are both significant on the 1% level. Although its coefficient decreases to 0.17, *LongLenLOW* remains economically significant. The coefficient of *LOWcrisis* suggests that during a crisis, *LOW* banks charge 14 basis points more than their peers. The general effect of *LOW* therefore seems to be the outcome of the combination of two factors: 1) *LOW* banks ask higher interest rates for loans with maturities longer than 30 days and 2) *LOW* banks increase the interest rates more drastically during crises. While the negative sign of *crisis* seems to be counterintuitive at first, it needs to be mentioned that we calculate spreads between the actual weighted interest rate and the respective ECB interest rate. Therefore, *crisis* suggests that the spread between the two rates is 80 basis points smaller during crises. The explanation for this is that after the failure of Lehman Brothers only a few banks remained active in the interbank money market. It can be assumed that the remaining institutions were more stable and were therefore able to borrow and lend at rates closer to the ECB interest rate. This explanation also holds on the international level given that Dutch banks were considered to be relatively stable compared to their international peers. Interestingly this does not hold for *LOW* banks as shown by the significant positive sign of *LOWcrisis*.

5.2. Borrowing Rates

Given the high correlation of the lending and borrowing rates of 0.8 and the implied similarity of results, we do not discuss the borrowing rates in detail but just point out the overall results and most important differences.

Generally speaking, *LOW* banks pay higher interest rates than their peers in the unsecured interbank money market. The effect of being in a crisis has a similar effect for borrowing and lending rates while the effect of longer maturities is smaller for the borrowing rates. In contrast to the lending rates, *LOW* banks do not pay significantly higher interest rates for longer maturities. The effect of the variables reflecting the riskiness of an institution have similar effects on borrowing and lending rates. Therefore, even when controlling for the riskiness of an institution, the compliance with the prudential liquidity requirement remains a significant factor when determining an institution's borrowing rate in the unsecured interbank money market.

This is an essential part of our analysis. The interest rate a bank has to pay in the interbank market is the outcome of negotiations between the two counterparts. As in any other contract, there is some sort of asymmetric information. Given the high sensitivity, it is reasonable to assume that a bank's regulatory liquidity position is not known to the lending bank while it will be able to obtain some basic information about the riskiness of its counterpart. In our model the riskiness is reflected by profitability, leverage and capital. Hence, if we control for the riskiness of an institution which usually determines the borrowing rate in the interbank market, we can conclude that the higher interest rates of *LOW* banks are caused by the willingness of these banks to pay higher prices and not by the behaviour of the lending bank. This conclusion is additionally confirmed by the nature of our fixed effects estimation which estimates adjustments of banks' behaviour in the time variation and not in the cross-sectional variation. It is highly unlikely that the lending bank can obtain information about its counterpart's fulfilment of the liquidity requirement over time but not of the before-mentioned balance sheet measures.

5.3. Total Lending

Table 2 presents the results for the analysis whether the introduction of a quantitative liquidity rule causes the ratio of total lending over total assets to decline.

Table 2: Effects of a quantitative liquidity rule on banks' lending volumes

VARIABLES	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
LOW	-3.402	8.072	6.478	2.480	-9.098	-10.06
	(8.429)	(9.115)	(9.150)	(14.07)	(14.22)	(14.24)
LOWcrisis		-43.78***	-42.49***	-48.46***	-20.85*	-20.09*
		(13.41)	(13.42)	(11.28)	(9.75)	(9.77)
profit			15.02*	25.16***	16.89**	17.92**
			(8.121)	(7.269)	(7.452)	(7.504)
LongLen				-13.00	-9.169	-7.820
				(9.314)	(9.297)	(9.370)
LongLenLOW				7.019	0.541	0.826
				(20.91)	(20.84)	(20.84)
crisis					-27.59***	-27.49***
					(6.073)	(6.073)
Lev						-1.227
						(1.064)
Constant	87.02***	86.99***	85.45***	62.54***	74.39***	81.99***
	(3.138)	(3.131)	(3.238)	(5.714)	(6.250)	(9.082)
Observations	2182	2182	2182	1691	1691	1691
r2_w	0.0007	0.0503	0.0662	0.1206	0.1327	0.1332

*Note:Columns 1-6 present fixed effects panel estimations with the percentage of total lending over total assets as dependent variable (henceforth Lending). Total lending is calculated as the monthly sum of loan value multiplied by maturity. The purpose of the above regressions is to show whether banks which are just above/below (LOW) their quantitative liquidity requirement lend smaller volumes than their peers. To show this, we additionally control for the riskiness of an institution ($profit$)) and the Basel III measures Lev (equity over total assets) and Capital (BIS capital ratio). Further, we include LongLen (share of loans with maturities longer than 30 days over total loans), LongLenLiqu which is an interaction term of LOW and LongLen as well as crisis (dummy which is 1 after the failure of Lehman and 0 otherwise) and LOWcrisis which is an interaction term of LOW and crisis. Statistical significance is indicated by *** p<0.01, ** p<0.05, * p<0.1 while standard errors are in parentheses*

Column 1 shows that *LOW* does not have an individually significant effect on *Lending*. Including however the interaction term *LOWcrisis* in column 2 shows that the fulfilment of the quantitative liquidity requirement has a significant effect on *Lending* after the failure of Lehman Brothers. During stress, *LOW* banks' *Lending* is 44% smaller than the lending of their peers. Given that the mean of *Lending* is 108% with a median of 37%, the results are economically significant.
Adding $profit$ in column 3 does not change the overall results considerably while being itself significant on the 10% level. The coefficient of $profit$ suggests that an absolute increase of a bank's profitability by 1%, increases *Lending* by 15%. Given that the average bank in our sample increases its profitability by about 0.5%, the effect is small but economically significant.
Similar to the regressions with respect to the interest rates, we add *LongLen* and *LongLenLOW* in column 4. Both variables enter all regressions nonsignificant, suggesting that while there is a combined effect of *LOW* on interest rates, for *Lending* the interaction of *LOW* and *crisis* seems to be more dominant. Adding *crisis* in the 4th regression confirms its high importance. In the specification of column 4, *crisis* absorbs a considerable share of the significance of both *LOWcrisis* and $profit$. The variable *crisis* itself is statistically significant on the 1% level with a coefficient of -27.6, suggesting that during crises *Lending* declines by about 27%.
In column 6, we additionally add *Lev*, an institutions leverage ratio. *Lev* is statistically insignificant and does not alter the overall results considerably.

6. Sensitivity Tests

In this section we present the sensitivity tests which we conducted to show the robustness of our results. In order to take into account the effects of the general liquidity position of a bank but also the difference between a bank which is still relatively close to the minimum liquidity requirement and a bank far away from meeting the threshold, we include the actual ratio of the liquidity requirement as continuous variable. Further, we split the dataset in large and small banks and finally re-run our model using a larger set of controls.
Adding a larger set of control variables changes the overall results with respect to interest rates not considerably. Unexpectedly, it reduces somewhat the coeffi-

cients and the significance of *LOW*, *LongLenLOW* and *LOWcrisis*. However, all the variables related to the fulfilment of the DLCR remain economically and statistically significant. The continuous variable of the liquidity requirement (*LRM*) does not have a dominant effect and is only statistically significant in one specification with economically small coefficient. Dividing the dataset in small and large banks yields relatively small changes while the effect of being just above/below the DLCR is slightly larger for bigger banks.
With respect to lending volumes, the effect of additional control variables is somewhat bigger. While *LOW* as well as *LongLenLOW* remain statistically insignificant, *LOWcrisis* loses some of its statistical but gaining some economic significance. Interestingly, *LRM* is generally significant on the 1% level, having a positive effect on *Lending*. A possible explanation for the large impact of the continuous liquidity ratio on total lending while there is almost no effect on the interest rates is the relatively small range of possible interest rates. It can be assumed that banks with very high liquidity ratios can lower the lending rates just until a certain point. The same situation applies for banks being very low on liquidity as these banks can only increase their interest rates up to some limit. For total lending the situation is different. Banks with a very high DLCR can lend as much as they want while banks with a very low DLCR are able to entirely stop lending.

7. Conclusion

The aim of this study is to show the effects of a binding regulatory liquidity requirement on the behaviour of banks in the unsecured interbank money market. Our results suggest that a binding regulatory liquidity requirement gives rise to banks paying and asking higher interest rates for unsecured interbank loans. These effects are larger for maturities longer than the LCR's 30 day horizon and increase after the failure of Lehman Brothers. During a crisis, being just above/below the prudential liquidity requirement induces a negative impact on lending volumes.
It is essential to note that there are important interactions between our results. Both, interest rates and actual volumes jointly determine the behaviour of a bank in the unsecured interbank money market. As established by our results, the general effect of a quantitative liquidity rule on interest rates is a combination of banks ask-

ing (paying) higher prices for longer maturities and banks asking (paying) higher prices during stress. For lending volumes, the main effect of the quantitative liquidity rule is exerted during stress, given that banks for which the rule is binding cut lending more drastically than their peers. Combining the results therefore leads to the conclusion that the negative effect of a quantitative liquidity rule on the interbank money market is particularly severe during stress.

As argued previously, the unsecured interbank money market is an essential instrument for the distribution and allocation of liquidity. A shrinking of this market alongside with skewed interest rates might therefore severely hamper the effectiveness of monetary policy. Given the high importance of monetary policy during stress in combination with our results suggesting that the negative effects of a quantitative liquidity rule are especially severe during recessions should set incentives for regulators to clarify the usage of the LCR's liquidity buffer alongside with establishing an extended buffer definition during stress.

Allowing banks to use their liquidity buffer during stress would dampen the negative effects of a quantitative liquidity requirement on the interbank money market. The reason for this is that if banks can use their liquid assets to cover outflows (as actually intended by the LCR), the liquidity requirement would be less binding with banks facing less incentives to increase interest rates and cut lending. A similar effect can be expected when extending the definition of liquid assets during stress. A potential extension would make it easier for banks to comply with their liquidity requirement, again making the rule less binding and therefore reduce its negative effects during stress on the interbank money market and more importantly on the effectiveness of monetary policy.

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Table .3: Effects of a quantitative liquidity rule on the BORROWING rates in the interbank money market

VARIABLES	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
LOW	0.206***	0.243***	0.294***	0.316***	0.340***	0.0924
	(0.0293)	(0.0299)	(0.0875)	(0.0864)	(0.100)	(0.0670)
LongBor		0.400***	0.411***	0.410***	0.411***	0.283***
		(0.0447)	(0.0485)	(0.0479)	(0.0488)	(0.0319)
LongBorLOW			-0.0675	-0.114	-0.121	0.137*
			(0.109)	(0.108)	(0.126)	(0.0819)
profit				0.104***	0.102***	-0.0127
				(0.0175)	(0.0177)	(0.0119)
Lev					-8.336**	1.345
					(4.116)	(2.692)
Capital					0.000516**	4.49e-05
					(0.000262)	(0.000171)
crisis						-0.740***
						(0.0163)
LOWcrisis						0.0818**
						(0.0401)
Constant	0.858***	0.567***	0.557***	0.552***	0.614***	0.984***
	(0.0110)	(0.0358)	(0.0389)	(0.0384)	(0.0502)	(0.0338)
Observations	2391	1978	1978	1960	1768	1768
r2_w	0.0206	0.0685	0.0686	0.0833	0.0923	0.616

Note:Columns 1-6 present fixed effects panel estimations. The regressions are the same as in 1. However, the dependent variable in this case is the spread between the monthly volume weighted average BORROWING rate and the respective ECB interest rate.

Table .4: Lending rates and a larger set of controls

VARIABLES	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
LOW	0.238***	0.114**	0.127**	0.115*	0.103*	-0.0288
	(0.0282)	(0.0574)	(0.0549)	(0.0586)	(0.0576)	(0.0358)
LRM	0.0235	0.0183	-0.000896	0.0143	0.0115	-0.0201**
	(0.0182)	(0.0144)	(0.0139)	(0.0140)	(0.0138)	(0.00834)
LongLen		0.0556	0.0543	0.0866**	0.167***	0.579
		(0.0387)	(0.0372)	(0.0367)	(0.0376)	(0.0532)
LongLenLOW		0.339***	0.273***	0.236***	0.290***	0.184***
		(0.0873)	(0.0837)	(0.0890)	(0.0878)	(0.0228)
profit			0.192***	0.189***	0.189***	0.0435**
			(0.0295)	(0.0301)	(0.0295)	(0.0181)
RoE			-0.257***	-0.273***	-0.273***	-0.124***
			(0.0749)	(0.0774)	(0.0761)	(0.0467)
cash			-0.00667***	-0.0353***	-0.0337***	-0.00330*
			(0.000685)	(0.00264)	(0.00260)	(0.00168)
Lev				-2.659	-3.197	2.673
				(4.159)	(4.086)	(2.475)
Capital				0.000487**	0.000319	-7.45e-05
				(0.000221)	(0.000219)	(0.000132)
NetLender					0.209***	0.0348**
					(0.0279)	(0.0172)
crisis						-0.739***
						(0.0155)
LOWcrisis						0.0993***
						(0.0345)
Constant	0.749***	0.708***	0.788***	0.846***	0.670***	1.049***
	(0.0273)	(0.0370)	(0.0365)	(0.0450)	(0.0500)	(0.0313)
Observations	2229	1730	1716	1571	1571	1571
r2_w	0.0318	0.0706	0.148	0.202	0.230	0.720

Note:This table presents the same regressions as Table 1 but with a larger set of controls. Namely, we additionally included LRM (the DLCR as continuous variable), cash, RoE and NetLender.

Table .5: Lending rates with a different sized banks

VARIABLES	(1) large	(2) large	(3) large	(4) small	(5) small	(6) small
LOW	0.278***	0.103*	-0.0378	0.220***	0.118**	-0.0285
	(0.0289)	(0.0576)	(0.0365)	(0.0289)	(0.0584)	(0.0372)
LongLen		0.0620	0.0730		0.0549	0.0440
		(0.0399)	(0.0548)		(0.0390)	(0.0559)
LongLenLOW		0.407***	0.171***		0.319***	0.171***
		(0.0894)	(0.0225)		(0.0903)	(0.0223)
profit			0.0103			0.00155
			(0.0106)			(0.00971)
Lev			1.735			2.796
			(2.855)			(2.529)
Capital			-0.000113			-0.000111
			(0.000131)			(0.000132)
crisis			-0.765***			-0.757***
			(0.0146)			(0.0144)
LOWcrisis			0.150***			0.145***
			(0.0357)			(0.0393)
Constant	0.772***	0.720***	1.045***	0.795***	0.748***	1.036***
	(0.0111)	(0.0237)	(0.0239)	(0.0102)	(0.0234)	(0.0225)
Observations	2010	1600	1460	2121	1624	1466
r2_w	0.0446	0.0858	0.724	0.0272	0.0649	0.711

Note:This table presents the same regressions as Table 1. However, in Columns 1 to 3 only large and in Columns 4 and 6 only small institutions are considered.

Table .6: Lending Volumes and a larger set of controls

VARIABLES	(1) FE	(2) FE	(3) FE	(4) FE	(5) FE	(6) FE
LOW	4.734	14.12	-0.130	-12.76	-3.825	-5.734
	(8.408)	(9.110)	(8.831)	(9.326)	(12.75)	(12.74)
LRM	27.67***	27.31***	20.87***	19.78***	13.75***	14.35***
	(3.854)	(3.845)	(3.716)	(3.712)	(3.115)	(3.115)
LOWcrisis		-40.70***	12.26	-35.85**	-21.48*	-23.35**
		(13.27)	(13.45)	(14.60)	(11.74)	(11.74)
profit		14.08*	19.18**	13.58	31.96***	34.64***
		(8.030)	(9.594)	(9.657)	(7.884)	(7.922)
RoE			-110.5**	-124.9**	-188.0***	-191.9***
			(52.85)	(52.78)	(40.06)	(39.99)
cash			-2.915***	-2.795***	-2.999***	-3.020***
			(0.210)	(0.212)	(0.161)	(0.161)
crisis				-25.61***	-12.76**	-12.40**
				(6.272)	(5.500)	(5.490)
LongLen					-14.99*	-12.03
					(8.310)	(8.355)
LongLenLOW					-7.008	-6.430
					(18.61)	(18.57)
Lev						2.736***
						(0.952)
Constant	32.73***	31.94***	64.82***	78.03***	65.42***	81.32***
	(8.174)	(8.184)	(8.209)	(8.795)	(8.624)	(10.23)
Observations	2182	2182	2182	2182	1691	1691
r2_w	0.0236	0.0295	0.111	0.118	0.230	0.234

Note:This table presents the same regressions as Table 2 but with a larger set of controls. Namely, we additionally included LRM (the DLCR as continuous variable), cash, RoE and NetLender.